documented. These sites were evaluated for: 1) potential to impact the cost of implementing a flood control alternative; and 2) suitability for implementation in view of the need to construct, operate and maintain an alternative in an environmentally safe manner. The evaluations were based upon Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) guidance. Ratings – low, moderate, and high - were assigned to the sites based on the probability of contamination. Table 5.6.1 presents the results for areas adjacent to the banks of Mill Creek. For ease of presentation, the results of other parts of the study area are not listed in the table. However, the evaluations presented are typical of results found for the remainder of the study area. Due to the highly industrial nature, the majority of the study area was assigned a moderate to high risk for the presence of hazardous materials. The full report of the evaluations can be found in the Field Observation & Study Report prepared by Altech Environmental Services (1998 and 2001).

**TABLE 5.6.1**
**Contamination Potential for Areas Adjacent to Mill Creek**

| Section | Site Description | Rating |
|---|---|---|
| 2 | Castellini Trucking Facility | Moderate |
| 4B | Village of Elmwood Place Dump | High |
| 4B | Center Hill Landfill | High |
| 4B | North Bend Road Dump | High |
| 4B | Vine Street Dump | High |
| 5 | No areas of concern identified | |
| 6 | Pristine Inc.- SUPERFUND SITE | High |
| 7A* | East bank-St. 1866 to 1955, industrial use & borings | High |
| 7A* | West bank- St. 1866 to 1905, waste disposal from industrial use | High |
| 7A* | West bank- St. 1905 to 1922, historical agricultural use | Moderate |
| 7A* | West bank- St. 1922 to 1943, adjacent industrial use | High |
| 7A* | West bank- St. 1943 to 1955, low CERCLA risk | Low |
| 7B | Both banks- Glendale-Millford Road to Sharon Creek, rail switching yard and general industrial use | Moderate |
| 7B | Lower Sharon Creek, drainage from switching yard and general industrial use | High |
| 7B | East bank- Sharon Creek to St. 1866, industrial use | Moderate |
| 7B | East bank- St. 1866 to Sharon Road, nearby industries and evidence of dumping in soil borings | High |
| 7B | West bank- Glendale-Millford Road to Sharon Creek, industrial use | Moderate |
| 7B | West bank- Sharon Creek to St. 1845, near chemical facility (Ashland Chemical) | Moderate |
| 7B | West bank-Ashland Chemical to St. 1864, industrial use | Moderate |
| 7B | West bank- St. 1864 to 1870, adjacent industrial use | High |
| 7B | West bank- St. 1870 to Sharon Road, rail line probably built with cinders. | Moderate |
| 7C | North of Crescentville Road near right descending bank of East Fork, debris disposal area | None assigned |
| 7C | Right descending bank of Mill Creek mainstem near the Airborne Express facility on the opposite bank, rust-colored seep | None Assigned |
| 7C | Left descending bank of East Fork on the Trinity Industries facility site, potential industrial waste pit | None assigned |

* Section 7A had a reported spill of hazardous material at the General Mills Plant as well as a reported leaking underground storage tank.

# 6. PROBLEMS, NEEDS, AND OPPORTUNITIES

This section describes the problems, needs, and opportunities associated with Mill Creek. They fall into three categories: flooding, ecosystem, and recreation.

## 6.1 FLOODING

The Mill Creek, Ohio, Flood Damage Reduction Project was originally authorized in response to repeated flooding of the Mill Creek watershed. Two types of conditions cause the flooding. First are winter or spring floods caused by the typical backwater flooding from the Ohio River basin, which centers on an axis along the Ohio River valley from southeastern Missouri to western New York. These include the floods of January 1913, January 1937, March 1945, January 1959, and March 1964. Second, severe thunderstorms cause flash floods such as those in July 1958, September 1971, May 1996, April 1998, and the most recent in July 2001.

The January 19-21, 1959, flood was caused by precipitation typical of great winter storms in the Ohio River basin when southerly winds transported a large mass of warm moist air from the Gulf of Mexico to the Ohio Valley. This system contacted a high-pressure system from the south Atlantic coast and a low-pressure system over the Great Plains, causing the axis of the storm to occur along the Ohio River from its mouth to Cincinnati. Rainfall of up to 6 inches was recorded with runoff being high due to antecedent rainfall that occurred on January 14-17, as well as the freezing weather conditions. This storm produced a peak discharge of about 5,600 cfs at the Reading, Ohio, USGS gaging station, corresponding to a 4% chance ("25-year") event. This storm caused about $3 million in damage. The 1959 storm led to the authorization of this project.

The April 16, 1998, flood was one of the most recent and typical summer floods. Rainfall depths varied throughout the upper half of the Mill Creek basin, in southern Butler County and northern Hamilton County (Sections 7A and 7C), where flood damages occurred, from about 2.0 inches at the Butler County Sewage Treatment Plant to about 4.2 inches at Sharonville, Ohio (Sections 7A and 7C). This 18-hour storm produced a peak discharge of about 2,700 cfs near the high damage area just downstream of the confluence of Mill Creek and East Fork Mill Creek (Section 7A), corresponding to between a 10% chance event ("10-year" flood event) and a 4% chance event ("25-year" flood event). In July 2001, widely scattered heavy rainfall in southwest Ohio, including the Mill Creek basin, caused flooding in the same damage area as the 1998 flood. Flooding for this site was slightly greater than in April 1998, with a frequency approaching a 4% chance (25-year). In surrounding drainage basins this rainfall approached 4 to 8 inches in about a one-hour duration. However, for the Mill Creek basin rainfall totals and intensities did not approach this level. The July 2001 flood caused millions of dollars in damages to the community of Sharonville alone.

In addition to the storms, erosion along the banks of Mill Creek has added to the debris that already clogs the creek in some places. These obstructions tend to exacerbate flooding during rainfall events.

Due to development within the floodplain, both in Hamilton County and Butler County, the amount of impervious surface is expected to increase. This will result in less storage in the floodplain and greater run-off. It is estimated that because of this development, the flood stages will increase until the year 2015. Table 6.1.1 displays the estimated number of structures that would be damaged for a range of flood events for both the existing and future conditions.

**TABLE 6.1.1**
**Structures Flooded (Existing and Future Conditions)**

| Frequency Flood | Number of Structures Flooded Existing (2002) | Future (2015) |
|---|---|---|
| 95% | 0 | 11 |
| 50% (2-year) | 3 | 37 |
| 20% (5-year) | 36 | 83 |
| 10% (10-year) | 235 | 269 |
| 4% (25-year) | 387 | 433 |
| 2% (50-year) | 556 | 575 |
| 1% (100-year) | 622 | 628 |
| 0.2% (500-year) | 663 | 668 |
| 0.1% (1000-year) | 663 | 668 |

See Appendix XIII for tables showing detailed Without-Project flood damage estimates by reach for both existing (year 2002) and future conditions (year 2015 and beyond). (Please note that the detailed values in this appendix were not indexed up to year 2002 price-levels, as were the damage and benefit data in the body and other tables of this report).

## 6.2 ECOSYSTEM

The ecosystem of Mill Creek has degraded over time due to heavy industrialization. Trees have been removed, debris has been deposited in the stream, and banks have eroded. Stakeholders are interested in attaining Modified Warmwater Habitat (MWH) designation and Warmwater Habitat (WWH) designation for various sections of Mill Creek. MWH applies to streams with extensive and irretrievable physical habitat modifications. Because of the extensive habitat modifications the biological criteria for warmwater habitat are not attainable. The ammonia and dissolved oxygen standards are less stringent than warmwater habitat.

Mill Creek has suffered environmental damage from pollution in the form of fecal coliform, nutrients, and industrial pollutants from direct runoff, CSOs, and leaking landfills. In December 2000, the Ohio EPA prepared a Total Maximum Daily Load (TMDL) Implementation Alternative for Mill Creek. This alternative targeted levels of water quality improvements attainable within the study area. Based on stakeholder input, the Ohio EPA has agreed to a watershed-based implementation strategy to achieve TMDL objectives. There are opportunities for the project to improve water quality in the creek through implementing combined flood control/CSO reduction features. Such an approach may also reduce or eliminate the need for other CSO facilities. Opportunities also exist for the project to assist in improving water quality by incorporating environmental features in the selected alternative.

## 6.3 RECREATION

Canoeists use Mill Creek only rarely because of adverse conditions. Many canoeists wear hip waders and rubber gloves to protect themselves from potential and perceived harm. No fishing takes place in the creek. A limited trailway along the creek does exist in some sections. This project is an opportunity to enhance recreational opportunities by improving water quality, creating trails and greenways, creating in-stream habitat enhancements, and planting trees.

The *Mill Creek Watershed Greenway Master Plan* (Fuller, Mossbarger, Scott, and May, June 1999) outlines viable recreational goals:

- Return Mill Creek to an attractive destination for local residents and visitors by restoring riparian corridor habitat throughout the watershed, initiating reforestation, and improving flora and fauna species diversity and number.
- Develop passive recreational facilities and parks along greenway lands close to where residents live, work, and play.
- Construct a comprehensive system of walking and biking trails on publicly owned or leased properties, which would also increase efficient transportation alternatives to city residents.
- Promote improved water quality to provide for the recreational use of waterways within the watershed, including fishing, canoeing, and swimming.
- Link historic and significant natural sites throughout the watershed with the greenway system to promote tourism and the connection of Mill Creek to the Buckeye Trail, the American Discovery Trail, the Ohio River Heritage Trail, the Ohio to Erie Trail, and the Toledo-Cincinnati Trail.
- Improve water and air quality within the watershed to benefit public health and allow education projects such as outdoor classrooms for biology, zoology, and geology.
- Work with agencies to improve water quality so that Mill Creek is designated as safe for human contact.
- Promote safety and security as key elements of the new recreational greenway system.
- Develop an intermodal transportation system that includes the trails (listed in the third bulleted section above) with bus, light rail, and ferry.

# 7. OBJECTIVES, CONSTRAINTS AND GENERAL REQUIREMENTS

## 7.1 OBJECTIVES

The authorized objective for the Mill Creek Project is flood-damage reduction. The GRR process will maintain agency and public involvement in the screening process and in the final GRR development in order to meet the primary authorized objective. The GRR may also provide an opportunity to incorporate ecosystem restoration and the development of recreational facilities. For the purposes of this screening level report, all three of these Corps-mission objectives were reviewed. As discussed in Section 2, selected alternatives should meet the ER-1105-2-100 criteria that the project be complete, acceptable, effective, and efficient.

### 7.1.1 Flood Reduction

- The selected alternative should provide flood-damage reduction.
- The analysis should consider the entire watershed with respect to causing no net rise in the 1% chance flood elevation elsewhere in the watershed.
- The selected alternative should be integrated with a Flood Warning System (FWS) to be implemented in the upper portion of the Mill Creek watershed in July 2003.

### 7.1.2 Ecosystem Restoration

- The selected alternative should incorporate ecosystem restoration measures that are consistent with the flood-damage reduction purpose of the project.
- The selected alternative should minimize disturbances to the remaining riparian corridor and aquatic habitat.
- The analysis should consider multiple ecosystem objectives. These could include aquatic and terrestrial ecosystem improvements and restoration.

### 7.1.3 Recreation

- Recreational features should be considered and incorporated into the selected alternative consistent with the financial capabilities of the sponsor and the goals of the *Mill Creek Watershed Greenway Master Plan.*

## 7.2 CONSTRAINTS

### 7.2.1 Regulatory

The approved alternative must meet the evaluation criteria of completeness, effectiveness, efficiency, and acceptability as presented in the USACE Planning Manual 96-R-21 and ER-1100-2-100.

The approved alternative should also meet the past requirements of ER 1105-2-100, including that it be economically justifiable, environmentally sustainable, publicly acceptable, and engineeringly feasible.

Additionally, the alternative must be in compliance with all local, regional, and state alternatives and policies. Alternatives should be formulated to maximize the beneficial effects and minimize the adverse impacts.

### 7.2.2 Socio-Economics

Socio-economic effects become constraints when careful consideration indicates a magnitude of impact that may influence project activities or progression. Considerations common to all alternatives, particularly surface alternatives, are the effects on residential, commercial, and industrial structures as well as on the infrastructure, which are subject to flooding. Damage and reconstruction costs associated with flood events have created the need for flood damage reduction. Also to be considered are the functions, operations, and activities centered on and carried out within these structures by their occupants. Given the highly industrial nature of the project area, certain activities (e.g., relocation of manufacturing facilities and/or plants and construction of flood protection structures) could prove to be costly. The functions, operations, and activities of others within the affected area, such as residential and commercial occupants, must also be evaluated. Business and residential relocations could potentially have considerable impact on area employment, community cohesion, property values, tax revenues, public facilities and services, and transportation. Land requirements and potential changes in land use are associated with each alternative and have varying potentials for realizing aesthetic and recreation benefits. Potential effects on business activity and economic growth, on public heath and safety, on surface water quality, and on the potential for controversy are additional areas for consideration[3].

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[3] Environmental justice issues were not thought to be a concern for any of the alternatives that were evaluated. Further consideration will be given to environmental justice issues and the effects on minority and low income populations during later stages of the GRR.

### 7.2.3 Natural Resources

*Wetlands*: Section 2, 4B, 5, 6, 7A, 7B, and 7C of Mill Creek were found to contain areas of riverine bottoms (permanently flooded habitat located within the Mill Creek floodplain) that could qualify as wetland habitat. Portions of the creek banks in all of the sections have wooded areas potentially containing wetland habitat. An area of bottomland hardwoods was noted north of the confluence of the Mill Creek main-stem and the East Fork in Section 7C. Small pockets of other wetland habitat were noted for all sections; however, these areas lie outside of the study area limits.

*Protected Species*: Sections 2, 4B, 5, 6, 7A, 7B, and 7C lie within the range of the endangered Indiana bat (*Myotis sodalis*), the threatened bald eagle (*Haliateetus leucocephalus*)., and the endangered running buffalo clover (*Trifolium stoloniferum*). Although there were no specific occurrences within 0.5 miles of either bank of Mill Creek, habitat favored by the Indiana bat (roosting and foraging) and the running buffalo clover may exist within the study area.

Upon examination of quadrangle maps provided by the USGS the ODNR identified other species and areas that could be of concern. The ODNR identified two state-listed species or special habitat areas including the threatened passion-flower (*Passiflora incarnata*) and the Rock Elm Ohio Champion Big Tree. Two plant communities, the Oak Maple Forest plant Community and the Mixed Mesophytic Alternativet Community were also identified.

The plant communities of Cincinnati and the surrounding area contribute to the diversity and abundance of the vegetation that is established within the Mill Creek Valley. The dominant woodland communities contribute seed sources to the Mill Creek and represent the principal species source for the region (exclusive of cultivars and introductions). The endemic vegetation of the surrounding area over time assist in shaping the potential successional development pattern that has occurred and is likely to occur in the future within the Mill Creek Valley area. As a consequence, the Native species (including threatened and endangered flora and fauna) of the surrounding geographic and ecological areas will have an influence on natural resource development within the study area.

### 7.2.4 Cultural Resources

A Phase I archaeological survey was conducted using techniques such as shovel testing, walkover, and soil probing to assess the cultural resources available within the Mill Creek, Ohio, Flood Control Project site. This survey identified five historic and three prehistoric sites over the length of the project area. Many of the sites appear to have been subject to a great amount of disturbance due to development and use or were found to contain limited archaeological resources. One site containing a limestone and cinder block foundation with nearby coal and coal piles may be a possible nomination to the National Register of Historic Places (NRHP).

Investigations were done for the segments designated for construction under the Mill Creek Ohio Flood Control Project. Sections 2, 4B, 5 and 6 contained two of the five historic sites: a pair of bridge abutments located on both banks of Mill Creek about 1,800 feet south of

Seymour Road and a historic foundation with associated artifact scatter. Section 7A contained no cultural resources or sites. Section 7B contained one historic site and the previously mentioned three prehistoric sites. The historic site is a limestone and cinder block foundation with nearby coal and coal piles. The purpose of the structure could have been residential or industrial use. The three prehistoric sites were small prehistoric lithic scatters and flakes. Section 7C enclosed two potential historic resources: a bridge abutment and a bridge near East fork. These sites are thought to be related, however, they are badly deteriorated and likely to have limited historic resources.

### 7.2.5 Water Quality

As required under the Clean Water Act, the State of Ohio has identified Water Quality Standards to be achieved as part of the TMDL program. The final TMDL Implementation Strategy for Mill Creek is likely to include more stringent controls on both point and non-point pollution sources, as well as restoration of riverine-riparian habitat. Any alternatives recommended as part of the Mill Creek Flood Control Project should be compatible with alternatives to improve water quality in Mill Creek. The implementation of a flood control alternative must not preclude or limit the success of the TMDL Implementation Strategy.

### 7.2.6 Hazardous, Toxic, and Radioactive Waste

Because the watershed has experienced over 150 years of use as an industrial corridor, several sites contain or are likely to contain HTRW materials. Consistent with the guidance in ER 1165-2-132, the USACE will not participate in cleaning up material regulated by CERCLA or by the Resource Conservation and Recovery Act (RCRA). Each section of the Mill Creek Project area was investigated to determine and identify HTRW concerns (see table 5.5.1, Section 5.5). The selected alternative should avoid known HTRW sites wherever possible. The local sponsor understands that remediation for any such materials encountered would be its responsibility if the site cannot be avoided.

Two areas are marked for total avoidance due to HTRW concerns: the Center Hill Landfill and the North Bend Dump. The Center Hill Landfill is located Northwest of Mill Creek. This large facility has been closed and has been monitored by the Ohio EPA and the Cincinnati Health Department. Due to local concern and risk considerations, no disturbance of the Center Hill Landfill is planned.

North Bend Dump is located on West North Bend Road in Cincinnati, Ohio. The site is adjacent to Mill Creek and Congress Run Creek. Frederick Steel Corporation is now located in the general location of the North Bend Dump. The site is listed on the Comprehensive Environmental Response Compensation, and Liability Information System (CERCLIS) as being a potential hazardous substance site. Records indicate foundry sand, and demolition wastes were disposed of at this site. Due to local concern and risk considerations no disturbance of the North Bend site is planned.

### 7.2.7 Real Estate

All of the alternatives considered would require the acquisition of land, easements, and in some instances relocations or buyouts of residences or commercial/industrial sites. Costs for the purchase of real estate as well as the availability of the land present an economic and/or legal constraint for any alternative chosen.

# 8. METHODOLOGY

## 8.1 ENGINEERING

An engineering analysis was performed for each of the alternatives considered for the screening-level analysis. A brief discussion of the analysis performed is presented in Section 10. The following briefly describes the general methodology used while studying the engineering aspect of each alternative.[4]

A number of the alternatives considered would involve the demolition of residential, commercial and/or industrial facilities. The demolition procedures were examined in light of hazardous substance concerns and special handling precautions that would be needed. Cincinnati Area Geographic Information System (CAGIS) mapping was used to identify structures and parcels that would be affected. The parcel data were used with the Hamilton County Auditor files to provide building information such as size and age. Careful review of the building information identified structures that would likely contain asbestos material. Costs were determined to safely remove and dispose of the asbestos containing material. Decontamination and demolition of storage tanks was also examined as part of the study. The building information was reviewed to determine industries that reported hazardous materials storage to the Hamilton County Disaster and Emergency Services office. Costs were determined to safely remove the hazardous materials and clean the vessels containing the hazardous materials for structures that would be demolished.

The presence of lead based paint in the structures was considered in developing demolition costs. Local agencies were contacted concerning handling and disposal requirements. Hamilton County does not have local lead based paint regulations. Demolition operations in Hamilton County follow the federal regulations. These regulations would require the demolition supervisor to establish the time-weighted average (TWA) for monitoring the air concentration during demolition operations, in accordance with the lead standard. The debris created from the demolition operation may be disposed of as ordinary institutional construction debris.

Due to more than 150 years of industrial usage along the mainstem of Mill Creek, contaminated soils remain in its banks. The 1998 Altech Field Observation & Study Report analysis was reviewed to determine what level of soil contamination may be encountered during construction activities of each alternative. In addition, property listings and mapping reports of industrial sites and regulated units were purchased. Parcels where existing soil would likely be impacted by CERCLA regulated materials were plotted on scale electronic drawings. Areas where CERCLA regulated materials were indicated were verified by comparison to CAGIS mapping. These areas were then compared to the alternatives set forth in the screening process. Efforts were made to avoid known HTRW sites during the design analysis. In particular, two

[4] For this screening-level analysis, risk and uncertainty were not factored into the design of the levees and floodwalls (e.g, elevation of top of floodwall) and contingencies were used for the cost estimation. Risk and uncertainty will be incorporated during later stages of the GRR.

major HTRW sites were avoided altogether – the Center Hill landfill and the North Bend Dump; the screening-level design layouts for many of the alternatives, particular for CM and CM-2, were routed to avoid these sites.

It was assumed that any contaminated materials disturbed during construction and demolition activities would be removed, transported, and disposed off-site at an approved landfill. Contaminated material would be left as-is in areas not disturbed during construction. When designing the features of the alternatives, such as I-walls and T-walls, the quantity of potentially contaminated soil that would be disturbed was calculated. Commercial disposal facilities were contacted to determine distances that contaminated materials would need to be transported. The haul distance was assumed to be 25 miles. The quantity and distance were used when developing the cost estimates.

In order to develop designs for floodwalls and levees, foundation investigations were conducted to determine soil type and composition. The subsurface investigations which have been performed from the 1970's to the present consisted of drilling approximately 750 borings along Mill Creek. Sampling methods consisted of drive (Standard Penetration Test – SPT), rock coring, bag (hand augering or test pits – where boring locations prohibited access for a drill rig), and undisturbed sampling. Laboratory testing of samples consisted of USCS classifications, moisture contents; Atterberg Limits, soil shear strength, and rock core testing. The subsurface materials encountered in each reach along the top of the existing bank show fill (brick, ashes, cinders, wood, asphalt, coal, weathered shale, concrete, gravel, glass, plastic, etc.) ranging from as little as a few feet to 30 feet.

Where floodwalls are needed, a typical I-Wall (15-ft wall height) and two typical T-Wall (20-ft and 25-ft wall height) sections were analyzed for this study. CASE programs CWALSHT and CTWALL were used to establish rudimentary geometry for the I-wall and T-walls, respectively. CWALSHT's analysis required a 36-ft embedment for a 15-ft floodwall with a total sheet pile of 51 ft. It was estimated that the sheet pile would require 15-inch width, and an additional 8 inches of concrete extending from the face of the sheet pile on the landside. It was subsequently determined that deflection in the 15 ft walls was excessive, and therefore the design of the walls will be refined in Stage 3. CTWALL uses a line of creep method to establish seepage beneath the floodwall, which can make for an unconservative evaluation of overturning stability with slightly increased dimensions. CTWALL's analysis required a 36-ft base width, 14-ft toe and a key of at least 7.4 in depth (submerged under 8 ft of soil) for a 25-ft floodwall. Also, a 20-ft floodwall would require a 28-ft base width, 9-ft toe, and a key of at least 5 ft in depth (submerged under 6 ft of soil). The base of each scenario was sloped 3.5V:1H.

Any new levees incorporated into the alternatives were designed with a 10-ft top width and a side slope of 3H: 1V. Where new levees would be constructed, it was assumed that an inspection trench would be excavated per the following:

1) if levee is less than 3 feet in height; no inspection trench would be required;
2) if levee is 3 to 6 feet in height; the inspection trench would be as deep as the levee is tall – 8 feet wide at the bottom with 1V to 1H sideslopes;

3) if levee is greater than 6 feet in height; the inspection trench would be 6 feet deep, 8 feet wide at the bottom with 1V on 1H sideslopes;
4) if the levee height exceeds 15 feet; flatter sideslopes of 1V on 4H would be constructed.

Strictly for this screening level analysis, the top elevation of floodwalls and levees were set 3 feet higher than the 1% chance ("100-year") flood elevations along the study streams. Because of the rapid rise of Mill Creek, it was assumed that any roads and railroads that cross this line of protection would require automatic closures to prevent floodwaters from entering the protected areas. The closures would consist of rolling gate closure structures with an estimated minimum base width of 25 ft. The operation and maintenance of these closures can be problematical and on-going maintenance is critical. Pumps and other forms of interior drainage would be required to remove stormwater from behind the floodwalls and levees.

The construction of artificial riffles to improve fish habitat and the planting of trees along the banks were considered in the design of alternatives. Riffle design would be composed of 3-foot diameter boulders spaced perpendicular to the stream spaced 6 ft apart on center for a width up to 75% of the channel bottom. Five rows of these riffles would be placed at each location with each row staggered with the upstream and downstream rows. These rows would be separated 7 ft on center. Locations of these riffle structures would be staggered, alternating between 500 ft and 1,000 ft along the channel. Trees would also be planted every 200 ft on both sides of the top of creek bank in areas where riffles are constructed.

The artificial riffles and plantings (these quantities for each varied from alternative to alternative) were included in the cost estimates for each alternative (where applicable) in keeping with the goal of good environmental design. Ultimately, such features may be in addition to or may be part of an environmental mitigation package included in a final recommended plan (when the GRR effort is complete). Strictly for purposes of this Stage 1 screening level evaluation, Table 8.1.1 shows the coarse assumptions that were made regarding the potential mitigation cost for each plan, based on the multi-disciplinary team's subjective estimation of impacts for each plan:

**TABLE 8.1.1**
**Assumed Mitigation Costs as a Percent of Construction Cost**

| Alternative | Team's Subjective Assessment of Overall Environmental Impacts | Assumed Mitigation Cost (as a % of Initial Construction Cost) |
|---|---|---|
| Total Relocation (RL) | very beneficial | 0 % |
| Non-Structural (NS) | minor negative impacts | 3 % |
| Non-Structural 2 (NS-2) | moderate negative impacts | 8 % |
| Non-Structural 3 (NS-3) | minor negative impacts | 3 % |
| Channel Modification (CM) | negative impacts | 10 % |
| Channel Modification 2 (CM-2) | moderate negative impacts | 5 % |
| Flood Wall & Levee (FW) | negative impacts | 10 % |
| Deep Tunnel (TU) | beneficial | 0 % |
| Deep Tunnel 2 (TU-2) | minor negative impacts | 3 % |

Note that 2 of the plans (RL and TU) were considered to have a net positive environmental impact. For these, it was assumed that zero mitigation would be required.

## 8.2 HYDROLOGY & HYDRAULICS

A detailed hydrologic model has been developed for the Mill Creek basin for both existing and future conditions using the USACE Hydraulic Engineering Center (HEC)-1 "Flood Hydrograph Package" computer program. This model is subdivided into a total of 29 sub-basins. Included in this model are drainage areas, lags based on times of concentration, and the Soil Conservation Service (SCS) curve numbers for each sub–basin.

Water surface elevations for all floods have been computed through the use of the computer program HEC-2, "Water Surface Profiles," and converted to HEC-RAS. Field-surveyed cross sections are obtained at all bridges and some natural sections near bridges. The field-surveyed cross sections were supplemented by CAGIS 2-foot contour mapping. Roughness coefficients, Manning's "n," are based upon field inspection of the channel and overbanks, reproduction of known highwater marks for the January 1959 and April 1998 floods, and reproduction of the rating curves at the USGS gaging stations at Reading and at Carthage.

Existing Conditions used in the Hydrology and Hydraulics analysis are based on 2002 conditions. Future conditions are estimated to occur in 2015 and to remain constant thereafter. Due to the timing of the hydrographs and the large drainage area that enters the basin downstream of where future development occurs, increases in the flow at the Barrier Dam are insignificant when comparing existing versus future conditions.

Because of the potential for development within the Mill Creek basin and the associated higher flows that would be caused by this development, it is critical to determine the very best estimate of future flows. Much of this potential development is located in Butler County. Potential future development can significantly increase the flood runoff in two ways. With this development, there will be an increase in impervious area within the Mill Creek basin with lesser rainfall infiltrating the ground, thereby causing more runoff. Butler County currently has a detention basin regulation that requires that the allowable peak rate of runoff shall not exceed a pre-developed 10% chance frequency storm. If development were allowed to occur in the floodplain, valuable floodplain storage would be reduced or lost, also causing significant increases in flow if other flood control measures are not implemented. Based upon the most reasonable projection of future conditions provided for these two counties, the hydrologic models are modified to account for this development. For instance, at the confluence of Mill Creek and East Fork Mill Creek just downstream of the county line, the 1% chance future flood flow is computed to be 5,840 cfs, an increase of 800 cfs from existing conditions.

To ensure that future flows will not increase further or perhaps be reduced, Butler County has contracted for the development of a floodplain management master alternative that identifies additional flood control measures that would be utilized to offset other development. The adoption and implementation of such an alternative would help ensure the future performance of flood control measures within Hamilton County.

It should be emphasized that for this screening-level analysis, the structural alternatives were designed to keep design flows off of buildings and roads, but not to necessarily maintain